MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2021/2022

EEL 3136 – ELECTRICAL DRIVES

(LE)

12 AUGUST 2022
9:00 AM to 11:00 AM
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 7 pages including cover page with 4 Questions only.
2. Answer ALL questions. All questions carry equal marks and the distributions of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

Question 1

a) A 20hp, 1400 rpm centrifugal pump is used to transfer water from lower tank to higher tank for a production line. The efficiency of pump is 67%. Assuming the pump runs at full load and at rated speed. Calculate the size for the electric motor to drive the pump system. Refer to Table Q1 for the motor selection table.

[4 marks]

b) The pump in (a) is now connected to a variable speed drive in order to control the speed. Resize the motor size if the lowest speed motor run is 380 rpm. Refer to Figure Q1(a) sizes 80-132 curve for derating factor.

[7 marks]

c) Explain the different between Duty S1 and S2 for an induction motor

[4 marks]

d) Estimate the mechanical power for the pump in (b) when motor runs at supply frequency 48Hz instead of 50Hz, at full load.

[4 marks]

e) Estimate the reduction in electrical energy per month when motor runs at 48Hz instead of 50Hz as in part (d). Given power loss is 10% of the total mechanical power. The pump runs for 12 hours/day for 25 days per month.

[6 marks]

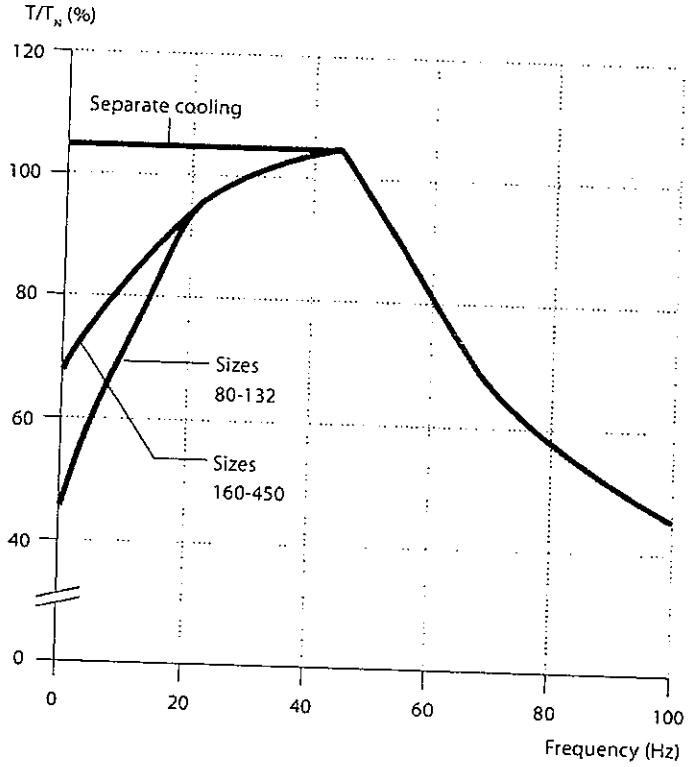

Figure Q1 – From ABB Motor Catalogue

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Table Q1

Technical data
IE2 cast iron motors, 1500 r/min

IP 55 - IC 411 - Insulation class F, temperature rise class B
IE2 efficiency class according to IEC 60034-30-1; 2014

Output kW	Motor type	Product code	Speed r/min	Efficiency IEC 60034-30-1; 2014 Full load 100%	3/4 load 75%	1/2 load 50%	Power factor Cos φ	Current I_N A	I_A/I_N	Torque T_N Nm	T_A/T_N	T_K/T_N
1500 r/min = 4 poles				400 V 50 Hz				CENELEC-design				
0.25	M3BP 71 MA 4	3GBP072321-••B	1365	68.3	70.8	69.7	0.81	0.65	3.5	1.74	1.9	2.0
0.37	M3BP 71 MB 4	3GBP072322-••B	1380	72.4	74.5	74.6	0.83	0.88	4.0	2.5	1.6	2.1
0.55	M3BP 80 MA 4	3GBP082321-••B	1415	74.5	73.8	70.0	0.73	1.45	5.0	3.7	2.0	2.8
0.75	M3BP 80 MD 4	3GBP082324-••B	1430	81.0	80.7	77.3	0.73	1.83	5.3	5.0	2.7	3.2
1.1	M3BP 90 SLB 4	3GBP092322-••B	1435	83.6	84.5	83.2	0.80	2.3	6.1	7.3	2.7	3.4
1.5	M3BP 90 SLD 4	3GBP092325-••B	1430	84.3	85.6	84.7	0.83	3.0	6.3	10.0	2.7	3.4
2.2	M3BP 100 LC 4	3GBP102323-••B	1450	85.9	85.1	83.4	0.78	4.7	8.8	14.4	3.7	4.1
3	M3BP 100 LD 4	3GBP102324-••B	1450	86.8	87.0	85.4	0.79	6.3	7.7	19.7	2.9	3.4
4	M3BP 112 MB 4	3GBP112322-••B	1440	86.8	87.7	87.3	0.81	8.2	7.0	26.5	2.5	2.9
5.5	M3BP 132 SMB 4	3GBP132322-••B	1460	89.0	89.8	88.9	0.80	11.1	5.9	35.9	1.7	2.4
7.5	M3BP 132 SMC 4	3GBP132323-••B	1450	89.3	90.1	90.0	0.81	14.9	5.6	49.3	1.6	2.4
11	M3BP 160 MLA 4	3GBP162031-••G	1466	90.4	91.6	91.3	0.84	20.9	6.8	71.6	2.2	2.8
15	M3BP 160 MLB 4	3GBP162032-••G	1470	91.4	92.3	92.2	0.83	28.5	7.1	97.4	2.6	3.0
18.5	M3BP 180 MLA 4	3GBP182031-••G	1477	91.9	92.8	92.6	0.84	34.5	7.2	119	2.6	2.9
22	M3BP 180 MLB 4	3GBP182032-••G	1475	92.3	93.3	93.2	0.84	40.9	7.3	142	2.6	3.0
30	M3BP 200 MLA 4	3GBP202031-••G	1480	93.2	94.0	93.7	0.84	55.3	7.4	193	2.8	3.0
37	M3BP 225 SMA 4	3GBP222031-••G	1479	93.4	93.9	93.4	0.84	68.0	7.1	238	2.6	2.9
45	M3BP 225 SMB 4	3GBP222032-••G	1480	93.9	94.3	93.9	0.85	81.3	7.5	290	2.8	3.2
55	M3BP 250 SMA 4	3GBP252031-••G	1480	94.4	94.9	94.6	0.85	98.9	7.0	354	2.6	2.9
75	M3BP 280 SMA 4	3GBP282210-••G	1484	94.5	94.5	93.9	0.85	134	6.9	482	2.5	2.8

Continued...

Question 2

A punching machine uses a DC motor, name plate is shown in Figure Q2. The machine is to operate in quadrant 1 and 2. The motor is driven by a three-phase full controlled rectifier with supply voltage 400V, 50Hz. The armature resistance of the motor is 0.2 Ω.

a) Explain quadrant 1 and 2 with help of a diagram, [5 marks]

b) Calculate the firing angle when the motor runs at 800 rpm and at half of the rated load. [10 marks]

c) Calculate the electric energy per month for the motor drive system operating as in part (b). Given the punching machine operates 9 hours/day for 30days. [6 marks]

d) State two preventive measures to be taken by the maintenance personnel when maintaining a DC drive. [4 marks]

ABB	
Motor Sep.	06-1995 IEC 34-1-1969
Type DMP 112-4L	No 1124 01659
12 5 kW	1500 r/min
Duty S1	Ins. Class F
Arm. 495 V	Arm. 29 9 A
Exc. 300 V	Exc. 2 18 A
IP 23S IC 06	IM 1001
Cat. No. FR 159 101-1A	123 5 kg
MADE IN FRANCE	FABRIQUE EN FRANCE

Figure Q2

Continued...

Question 3

a) The induction motor has the following nameplate (figure Q3a) and windings parameters. The Variable Speed Drives (VSD)is operated with a constant (V/f) control up to 50Hz and at rated voltage above 50Hz.

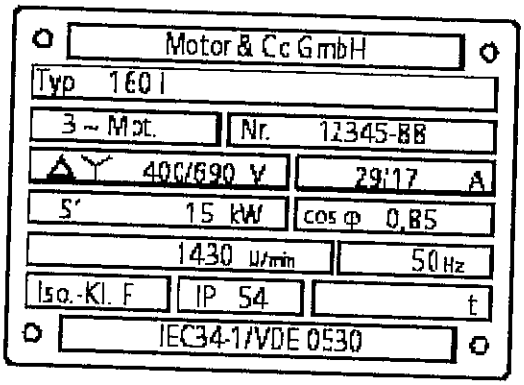

Figure Q3a

$R_S = 2.0\Omega,\ R_r' = 2.1\Omega,\ X_S = 2.5\Omega,\ X_r' = 3.0\Omega$

i) Determine and sketch the type of the connection to the motor terminal, supply voltage is 400V, 50 Hz.

[5 marks]

ii) Calculate the breakdown torque for a frequency of 30 Hz for motoring operation.

[4 marks]

Given

$$T_{max} - \frac{3}{2\omega_{ms}}\left[\frac{V^2}{R_s \pm \sqrt{R_s^2 + (X_s + X'_r)^2}}\right]$$

iii) Calculate the supply frequency for motoring operation at 1000 rpm and at full-load torque.

[4 marks]

Continued...

b) Speed-torque curve for an induction motor driven by a soft-starter is shown in Figure Q3b. Explain the relationship of load torque and the motor phase voltage.

Legends
ω_m – Motor Speed (rad/sec)
ω_{ms} – Motor Synchronous speed (rad/sec)
V – motor phase voltage 1
V' – motor phase voltage 2
T – Motor Torque
T_L – Load torque

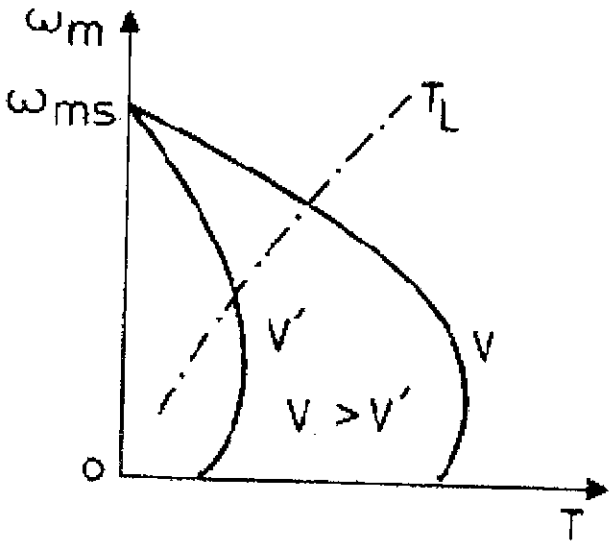

Figure Q3b

[6 marks]

c) One of the issues in power system when variable speed drives are installed is Harmonics. State three effects to the power system due to harmonics and suggest three solutions to suppress the harmonic.

[6 marks]

Continued...

Question 4

a) State three reasons why Switched Reluctance Motor is more favorable than induction motors for electric vehicle application.

[6 marks]

b) Explain with a sketch the working principle of a switched reluctance motor.

[7 marks]

c) Name and explain the two types of Permanent Magnet Synchronous Motors (PMSM) and state two reasons why they are suitable for electric vehicle applications.

[8 marks]

d) State two advantages and disadvantages of a variable reluctance stepper motor.

[4 marks]

End of Paper